Mustansiriyah University
College of Dentistry
Endodontics lectures
Fifth year

NiTi Rotary File II

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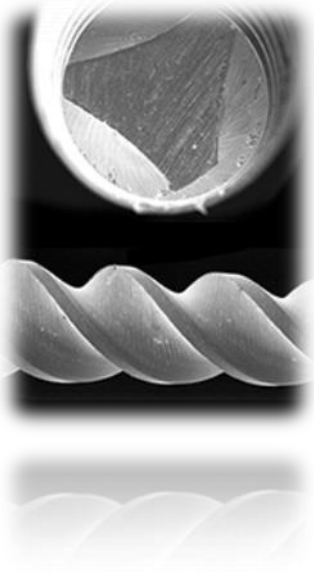
Generations of NiTi files systems

Since the beginning of modern day endodontics, there have been numerous concepts, strategies, and techniques for preparing canals. Over the decades, a staggering array of files has emerged for negotiating and shaping canals. In spite of the design of the file, the number of instruments required, and the surprising multitude of techniques advocated, endodontic treatment has been typically approached with optimism for probable success. The clinical endodontic breakthrough was progressing from utilizing a long series of stainless steel (SS) hand files and several rotary Gates Glidden drills to integrating nickel titanium (NiTi) files for shaping canals. Regardless of the methods utilized, the mechanical objectives for canal preparation were brilliantly outlined almost 40 years ago by Dr. Herbert Schilder. When properly performed, these mechanical objectives promote the biological objectives for shaping canals, 3-D disinfection, and filling root canal systems.

In 1988, Walia proposed Nitinol, a NiTi alloy for shaping canals, as it is 2-3 times more flexible, in the same file sizes, compared to stainless steel. A game-changing outcome of files manufactured from NiTi was that curved canals could be mechanically prepared utilizing a continuous rotary motion. By the mid-1990s, the first commercially available NiTi rotary files had come to market. The following is a mechanical classification of each generation of file systems. Rather than identify the myriad of available cross-sections, files will be characterized as having either a passive vs. an active cutting action.

FIRST GENERATION



To appreciate the evolution of NiTi mechanical instruments, it is useful to know that, in general, first generation NiTi files have *passive* cutting radial lands and fixed tapers of 4% and 6% over the length of their active blades. This generation of technology required numerous files to achieve the preparation objectives. By the mid to late 1990s, GT files *(Dentsply Tulsa Dental Specialties)* became available that provided a fixed taper on a single file of 6%, 8%, 10%, and 12%. The single most important design feature of first generation NiTi rotary file was passive radial lands, which encouraged a file to stay centered in canal curvatures during work.

SECOND GENERATION

The second generation of NiTi rotary files came to market in 2001. The critical distinction of this generation of instruments is they have *active* cutting edges and require fewer instruments to fully prepare a canal. To discourage taper lock and the resultant screw effect associated with both passive and active fixed tapered NiTi cutting instruments, EndoSequence *(Brassler USA)* and BioRaCe *(FKG Dentaire)* provide file lines with alternating contact points. Although this feature is intended to mitigate taper lock, these file lines still have a fixed tapered design over their active portions. The clinical breakthrough occurred when ProTaper *(Dentsply Tulsa Dental Specialties)* came to market utilizing multiple *increasing* or *decreasing* percentage tapers on a single file. This revolutionary, progressively tapered design limits each file's cutting action to a specific region of the canal and affords a shorter sequence of files to safely produce deep Schilderian shapes. During this period, manufacturers began to focus on other methods to increase the resistance to file separation. Some manufacturer's electro-polished their files to remove surface irregularities caused from the traditional grinding process. However, it has been clinically observed and scientifically reported that electropolishing dulls the sharp cutting edges. As such, the perceived advantages of electropolishing were offset by the more undesirable inward pressure required to advance a file to length. Excessive inward pressure, especially when utilizing fixed tapered files, invites taper lock, the screw effect, and excessive torque on a rotary file during work. To offset deficiencies in general, or inefficiencies resulting from electro-polishing, more cross-sectional designs have become available and increased, yet more dangerous, rotational speeds are advocated.

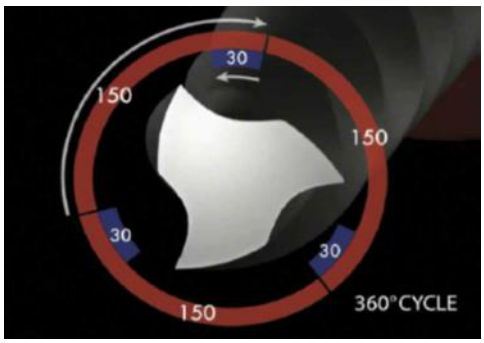
THIRD GENERATION

Improvements in NiTi metallurgy became the hallmark of what may be identified as the 3rd generation of mechanical shaping files. In 2007, manufacturers began to focus on utilizing heating and cooling methods to reduce cyclic fatigue and improve safety when rotary NiTi instruments work in more curved canals. The desired phase-transition point between martensite and austenite can be identified to produce a more clinically optimal metal than NiTi, itself. This 3rd generation of NiTi instruments significantly reduces cyclic fatigue and, hence, broken files. Examples of

brand lines that offer heat treatment technology are Twisted File *(SybronEndo)*, Hyflex *(Coltene Whaledent)* and GT, Vortex, and WaveOne *(Dentsply Tulsa Dental Specialties)*.

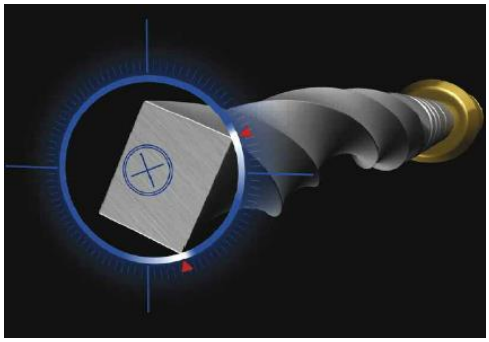
FOURTH GENERATION

Advancement in canal preparation procedures utilizes reciprocation, which may be defined as any repetitive up-and-down or back-and-forth motion. This technology was first introduced in the late 1950s by the French dentist, Blanc. Currently, the M4 *(SybronEndo)*, Endo Express *(Essential Dental Systems)*, and Endo-Eze *(Ultradent)* are examples of systems that use a movement where the clockwise (CW) and counterclockwise (CCW) degrees of rotation are absolutely equal. As compared to full rotation, a reciprocating file that utilizes an equal bidirectional movement requires more inward pressure to progress, will not cut as efficiently as a same-size rotary file, and is more limited in auguring debris out of the canal. From these earlier experiences, innovation in reciprocation technology led to a 4th generation of instruments for shaping canals. This generation of instruments and related technology has largely fulfilled the long hoped-for single-file technique. ReDent-Nova *(Henry Schein)* introduced the Self Adjusting File (SAF). This file has a compressible open tube design that is purported to exert uniform pressure on the dentinal walls, regardless of the cross-sectional configuration of the canal. The SAF is mechanically driven by a handpiece that produces both a short 0.4 mm vertical amplitude stroke and vibrating movement with constant irrigation. Another emerging single-file technique is termed One Shape *(Micro Mega)*, to be mentioned further in 5th generation designs. By far the most popular single-file concept is termed WaveOne *(Dentsply Tulsa Dental Specialties and Maillefer)* and Reciproc *(VDW)*. WaveOne represents a convergence of the best design features from the 2nd and 3rd generation of files, coupled with a reciprocating motor that drives any given file in *unequal* bidirectional angles. The CCW engaging angle is 5 times the CW disengaging angle and is designed to be less than the elastic limit of the file. Strategically, after 3 CCW and CW cutting cycles, the file will have rotated 360º, or one circle. This novel reciprocating movement allows a file to more readily progress, efficiently cut, and effectively auger debris out of the canal.



FIFTH GENERATION

The 5th generation of shaping files has been designed such that the center of mass and/or the center of rotation are offset. In rotation, files that have an offset design produce a mechanical wave of motion that travels along the active length of the file. Like the progressively percentage tapered design of any given ProTaper file, this offset design serves to further minimize the engagement between the file and dentin. In addition, an offset design enhances augering debris out of a canal and improves flexibility along the active portion of a ProTaper Next file.



Commercial examples of file brands that offer variations of this technology are Revo-S, One Shape *(Micro Mega)* and ProTaper Next *(Dentsply Tulsa Dental Specialties/Dentsply Maillefer)*. Today, the safest, most efficient, and simplest file systems utilize the most proven design features from the past, coupled with the most recent technological advancements currently available.